

Revolutionary Vertical Lift Technology Project

A blue NASA RVLT aircraft is shown in flight, hovering over a city skyline at sunset. The aircraft has four large vertical lift fans mounted on its wings and fuselage. The NASA logo and 'RVLT' are visible on the side of the aircraft. The background features a city skyline with various skyscrapers under a sky with scattered clouds.

Develop and validate tools, technologies, and concepts to improve future vertical lift vehicles with a focus on Urban Air Mobility (UAM)

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Fort Worth, Texas
<https://www.sae.org/aerotech>

NASA's RVLТ Project Provides Tools and Design Practices for UAM eVTOL Vehicles

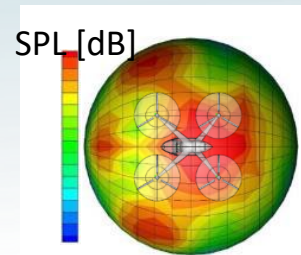
Noise Research



Human Response to UAM Noise



UAM Acoustic Impacts



Predictive Tools for UAM Noise



Share technical insights and lessons learned



SDOs



Safety Research



Crashworthiness & Occupant Protection



Handling Qualities



Electric Powertrain Reliability

NASA RVLT Project Research Areas

Ames Research Center

- Aeromechanics
- System Analysis
- Computational Methods
- Experimental Capability
- Flight Dynamics & Control
- Acoustics

Center Liaison: Gina Willink

Armstrong Flight Research Center

- UAM Handling and Ride Qualities
- UAM Electric System and Flight Control Integration

Center Liaison: Robert Navarro

Glenn Research Center

- Hybrid/ Electric Systems
- Electro-Mech Powertrains
- Icing
- System Analysis
- Impact Dynamics
- Acoustics

Center Liaison: Devin Boyle

Langley Research Center

- Acoustics
- Computational Methods
- Aeromechanics
- Experimental Capability
- Impact Dynamics
- System Analysis

Center Liaison: Benny Lunsford



Resources and Facilities

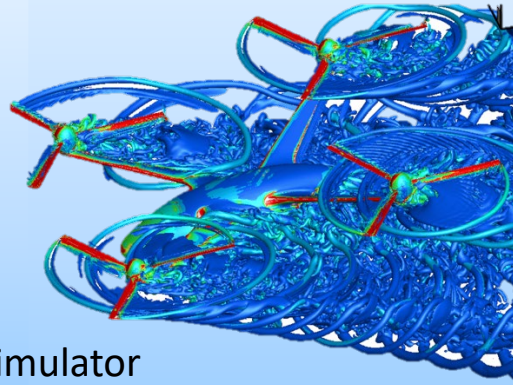


FY22/23 RVLT Summary

~113/113 Civil Service Workforce
~ \$34M/35M per year (includes salary)

Ames Research Center

- National Full-Scale Aerodynamics Complex (NFAC)
- Supercomputing Complex (NAS)
- Vertical Motion Simulator



Armstrong Flight Research Center

- Simulators
- Integration facilities
- Test range



Glenn Research Center

- Power, Motor and Transmission Test Facilities (ERB)
- Icing Research Tunnel



Langley Research Center

- 14- by 22-Foot Subsonic Tunnel
- Transonic Dynamics Tunnel
- Low-Speed Aero-acoustic Wind Tunnel
- Exterior Effects Synthesis & Sim Lab
- Mobile Acoustics Facility

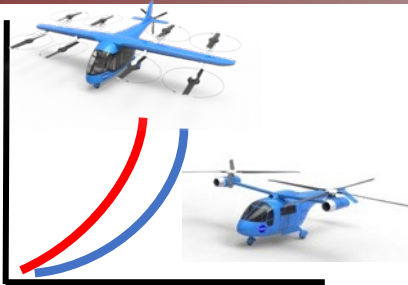


Revolutionary Vertical Lift Technology Project

Research Focus – Vehicle Noise and Safety



Noise and Performance



Tools to Explore the Noise & Performance of Multi-Rotor UAM Vehicles

- Plan and conduct validation experiments
- Improve efficiency & accuracy of conceptual design tools
- Deliver design and analysis tools to OGA & US community

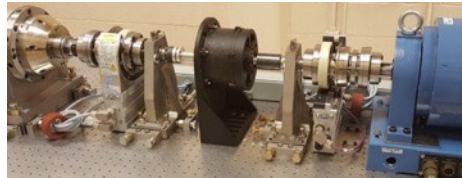
UAM Fleet Noise



UAM Operational Fleet Noise Assessment

- Generate Noise Power Distance (NPD) database for several UAM ref. configurations & trajectories
- Evaluate AEDT for UAM fleet noise assessments; provide feedback on findings & usage
- Develop empirical models for audibility & annoyance of UAM vehicles

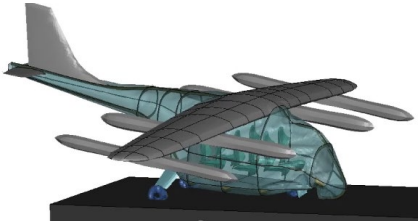
Electric Powertrain Reliability



Reliable & Efficient Propulsion Components for UAM

- Complete upgrades in labs for electric propulsion testing
- Develop tool, models, and analysis methods for electric propulsion concepts and components
- Develop design and test guidelines for eVTOL propulsion & thermal components

Occupant Safety



UAM Crashworthiness and Occupant Protection

- Conduct full-scale and component level tests
- Develop test guidelines, modeling best practices, and vehicle technologies for crash mitigation
- Deliver crash and impact data to consensus standards organizations

Handling & Ride Qualities

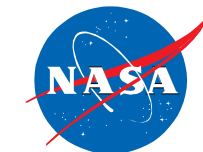


Acceptable Handling and Ride Qualities for UAM

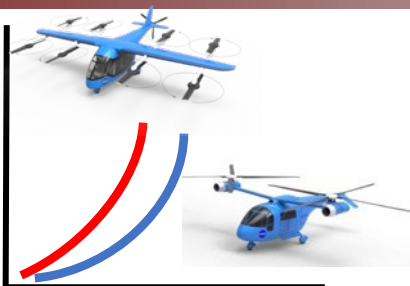
- Conduct human subject testing to assess handling and ride qualities
- Establish handling and ride qualities guidelines for UAM vehicles
- Develop flight dynamics and control modeling tools for conceptual design

Revolutionary Vertical Lift Technology Project

Research Focus; Recent Progress



Noise and Performance

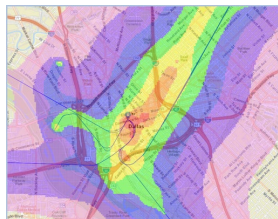


Tools to Explore the Noise & Performance of Multi-Rotor UAM Vehicles

- Plan and conduct validation tests
- Improve efficiency & accuracy
- Deliver design and analysis tools

Conducted Toolchain Workshop for US industry. Completed validation tests in the LaRC 14x22 and ARMY/ARC 7x10 wind tunnels.

UAM Fleet Noise

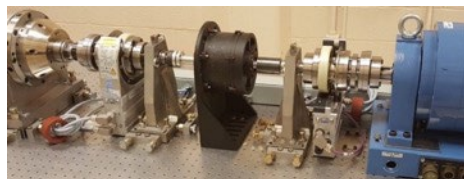


UAM Operational Fleet Noise Assessment

- Generate Noise Power Level
- Evaluate AEDT for UAM
- Develop empirical models

Completed Gen-3 UAM Fleet Noise assessment using AEDT – recommendations for AEDT modifications for UAM coming in FY23.

Electric Powertrain Reliability

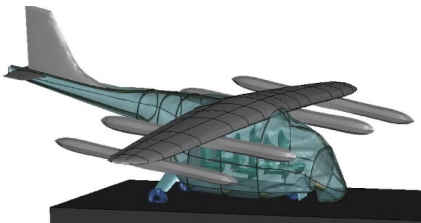


Reliable & Efficient Propulsion Components for UAM

- Complete upgrades in
- Develop tool, models, &
- Develop design and test

Reconfigurable electric propulsion labs operational (up to 200 kW, 1000V). Designed to inform AS-7499 & AS-8441.

Occupant Safety



UAM Crashworthiness and Occupant Protection

- Conduct full-scale and
- Develop test guidelines
- Deliver crash and impact

Full-scale composite cabin test article impact test completed in Nov. Data analysis underway and future testing in planning stage.

Handling & Ride Qualities



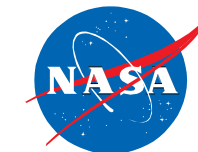
Acceptable Handling and Ride Qualities for UAM

- Conduct human subject
- Establish handling and
- Develop flight dynamic

Completed second Vertical Motion Simulator handling quality test. Data analysis underway; second Ride Quality test planned for FY23.

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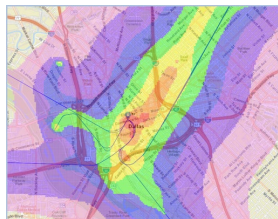
Research Focus; **FAA & Standards Org Interactions**



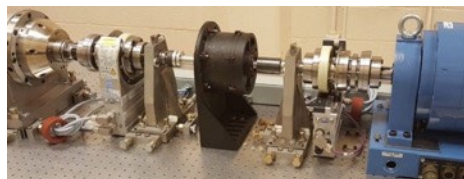
Noise and Performance



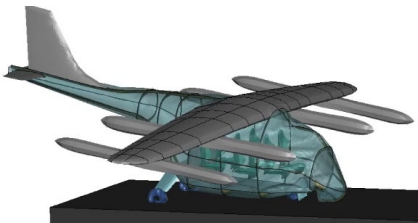
UAM Fleet Noise



Electric Powertrain Reliability



Occupant Safety



Handling & Ride Qualities



Tools to Explore the Noise & Performance of Multi-Rotor UAM Vehicles

- Plan and conduct validation
- Improve efficiency & accuracy
- Deliver design and analysis tools to OGA & US community
- NASA/FAA UAM Aircraft Design & Development Working Group

UAM Operational Fleet Noise Assessment

- Generate Noise Power Level
- Evaluate AEDT for UAM
- Develop empirical models
- Agreement with FAA on UAM community response test planning
- ICAO WG1 N.06 ETA Subgroup
- SAE A-21 development of noise sphere guidance

Reliable & Efficient Propulsion Components for UAM

- Complete upgrades in IEC
- Develop tool, models, & test
- Develop design and test
- SAE AE-7 Aerospace Electrical Power and Equipment Committee
- SAE AE-10 High Voltage Committee
 - AE-7A AS-8441 Permanent-Magnet Propulsion Motors & Drives
 - AE-7C AS-7499 High Voltage DC Power Quality

UAM Crashworthiness and Occupant Protection

- Conduct full-scale and component
- Develop test guidelines
- Deliver crash and impact
- ASTM D30 Committee on Composite Materials
- ASTM F44 WK68781 Means of Compliance for Dynamic Response
- ASTM F44 WK68805 Bird Strike Requirements
- SAE G-28 AS-6940 Simulants for Impact and Ingestion Testing

Acceptable Handling and Ride Qualities for UAM

- Conduct human subject testing to assess handling and ride qualities
- Establish handling and
- Develop flight dynamics and control modeling tools for conceptual design
- NASA/FAA UAM Aircraft Design & Development Working Group

Standards Development – SAE Standards



AE-10 and AE-7 Committee Involvement

AS7499 - Aircraft High Voltage Power Quality Standard

- Source/load requirements and verifications
- Stability Margins
- Fault Recovery
- Drives industry towards a 'plug and play' approach



AEROSPACE STANDARD	AS7499	REV. NEW
	Issued Revised Reaffirmed Stabilized Cancelled Superseding XXXX	xxxx-xx xxxx-xx xxxx-xx xxxx-xx xxxx-xx
Aircraft High Voltage DC Power Quality Standard		

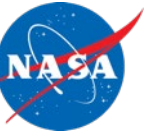
AS8441 – Minimum Performance Standard for Permanent Magnet Propulsion Motors and Associated Drives

- Using PM machine as baseline
- PM-driven electric engines
- Design guidelines for the motor/drive/controller integrated system (electric engine)



AEROSPACE STANDARD	AS 8441	REV. NEW
	Issued Revised Reaffirmed Stabilized Cancelled Superseding XXXX	xxxx-xx xxxx-xx xxxx-xx xxxx-xx xxxx-xx
Minimum Performance Standard for Permanent-Magnet Propulsion Motors and Associated Drives		

Aeronautics Reconfigurable Electrified Aircraft Lab (AREAL)

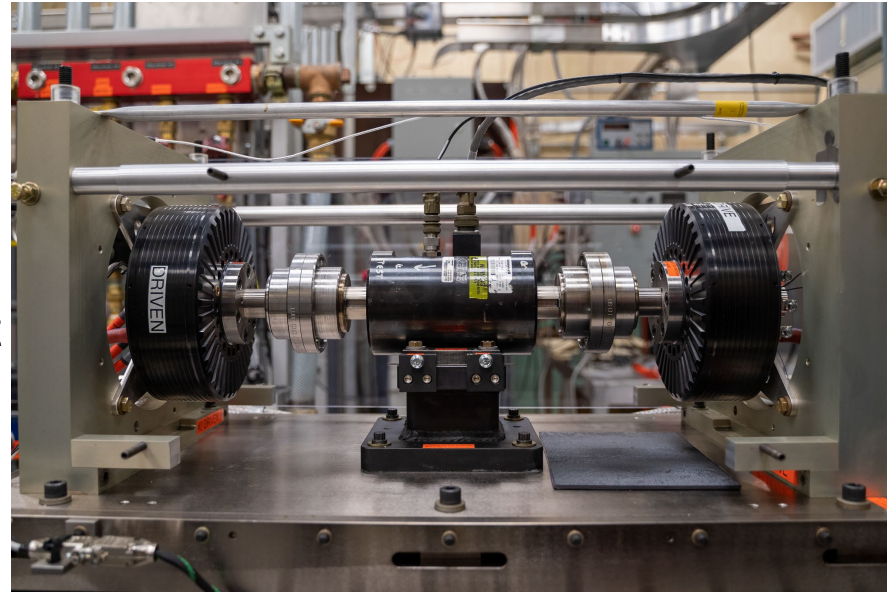


Capabilities

- 1 kVDC peak
- 200 kW nominal source capacity
- Emulated, reconfigurable system
 - Single-string, multi-string
- Power quality investigations
- Fault capability

Testing

- Nominal, transient, fault operation
- Characterization and response



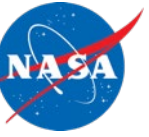
Summary

- NASA is focused on:
Advanced Air Mobility as one of the priorities for Aeronautics research
- RVLT is focused on:
VTOL research and technology to improve noise and safety of Urban Air Mobility vehicles



The RVLT vision is to create a future where VTOL configurations operate quietly, safely, efficiently, affordably, and routinely as an integral part of everyday life.

Backup





RVLT Technical Team

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